Subdural drainage versus subperiostal drainage in burr-hole trepanation for symptomatic chronic subdural hematomas

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Abstract: BACKGROUND: Symptomatic chronic subdural hematoma (scSDH) is one of the most frequent diseases in neurosurgical practice, and its incidence is increasing. However, treatment modalities are still controversial. OBJECT: The aim of this retrospective single-center study is to compare for the first time two surgical methods in the treatment of subdural hematoma that have been proven to be efficient in previous studies in a direct comparison. METHODS: We analyzed the data of 143 scSDHs in 113 patients undergoing surgery for subdural hematoma with placement of subperiostal or subdural drainage after double burr-hole trepanation for hematoma evacuation. RESULTS: Overall, there were no statistically significant differences regarding general patient characteristics, preoperative and postoperative symptoms, postoperative hematoma remnant, rates of recurrences, mortality, complications, and outcome at discharge and at 3-month follow up between the groups. There was a close to significant tendency of lower mortality after placement of subperiostal drainage system and a tendency towards lower rate of recurrent hematoma after placement of subdural drainage system. CONCLUSIONS: Our study shows for the first time a direct comparison of two mainly used surgical techniques in the treatment of scSDH. Both methods proved to be highly effective, and general patient data, complications, outcome and mortality of both groups are equal or superior compared with previously published series. Because there is a clear tendency to less mortality and fewer serious complications, treatment with double burr-hole trepanation, irrigation, and placement of subperiostal drainage is our treatment of choice in patients with predictable high risk of complications.

DOI: https://doi.org/10.1016/j.wneu.2011.05.036

Subdural drainage vs. subperiostal drainage in burr hole trepanation for symptomatic chronic subdural hematomas

A single centre experience of 113 cases

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Abstract:

Background: Symptomatic chronic subdural hematoma (scSDH) is one of the most frequent diseases in neurosurgical practise with an increasing incidence. However treatment modalities are still controversial.

Objective: The aim of this retrospective single centre study is to compare for the first time two surgical methods in the treatment of subdural hematoma, which have been proven to be efficient in previous studies, in a direct comparison.

Methods: We analyzed the data of 143 scSDH in 113 patients undergoing surgery for subdural hematoma with placement of subperiostal or subdural drainage after double burr hole trepanation for hematoma evacuation.

Results: Overall there were no statistically significant differences regarding general patient characteristics, preoperative and postoperative symptoms, postoperative hematoma remnant, rates of recurrences, mortality, complications and outcome at discharge and at three month follow up between the groups. There was a close to significant tendency of lower mortality after placement of subperiostal drainage system and a tendency towards lower rate of recurrent hematoma after placement of subdural drainage system.

Conclusions: Our study shows for the first time a direct comparison of two mainly used surgical techniques in scSDH treatment. Both methods proved to be highly effective and general patient data, complications, outcome and mortality of both groups are equal or superior compared to previously published series. As there is a clear tendency to less mortality and less serious complications the treatment with double burr hole trepanation, irrigation and placement of subperiostal drainage is our treatment of choice in patients with predictable high risk of complications.

Keywords:

Subdural hematoma, subdural drainage, subperiostal drainage, burr hole trepanation

Introduction:

Symptomatic chronic subdural hematoma (scSDH) was first described by Virchow in 1857 as “pachymeningitis haemorrhagica interna” and is nowadays one of the most frequent diagnosis in neurosurgical practice [3,5,18]. Incidence is reported to be between 1.7 and 13.1 per 100.000 inhabitants per year [3,5] and as scSDH is mainly found in elderly patients there has been a steady increasing incidence due to prolonged life expectancy in developing countries in recent years [1,5]. Therapeutic options include non-surgical or surgical management by means of craniotomy, burr hole trepanation or twist drill craniostomy. In general, surgical treatment is recommended in case of neurological symptoms [1,2,5,7,9-13,17,19,20]. In those cases double burr hole trepanation is the surgical method of choice as studies showed the best outcome in patients treated with double burr hole trepanation combined with irrigation and placement of a closed drainage system at first diagnosis of scSDH [8,19]. Furthermore, a recent prospective study showed that the use of a subdural drain after burr-hole trepanation is safe and associated with reduced recurrence and mortality [14].

Nevertheless, up to now there are only few class (II) evidence and no class (I) evidence publications in the literature on the treatment of scSDH.

Recent development in surgical treatment of scSDH includes a study of Zumofen et al analyzing a closed subperiostal drainage system instead of the commonly used subdural drainage system [20]. Remarkably their results regarding outcome, complications and postoperative symptoms were equal or superior to previously published studies[5]. Moreover a drainage system, which is not positioned in direct

contact to cortical structures, bridging veins or hematoma membranes seems to prevent more likely postoperative seizures and severe complications [20]. However there is no comparative study that evaluates that evaluates the advantages of the subperiostal drainage placement compared to subdural drainage placement. The present study compares for the first time the technique of subperiostal drainage with the more commonly used method of subdural drainage in a single-centre study including the same surgeons and the same pre-, peri- and postoperative mamagement for both study groups.

Clinical material and methods

General patient data:

In a retrospective study we reviewed the data of 113 patients who underwent surgery for symptomatic chronic subdural hematomas from 2007 to 2009 at the Department of Neurosurgery, University Hospital Zurich. Inclusion criteria consisted of patients receiving double burr hole trepanation, intraoperative irrigation and placement of subdural or subperiostal closed drainage system as the first surgical treatment. A total number of 113 patients receiving surgery for 143 symptomatic chronic subdural hematoma were included and analyzed. The patients were divided into two groups according to the drainage system used intraoperatively. General patient data including age, sex, secondary diagnosis, medication and other risk factors as well as preoperative symptoms, Glasgow Coma Scale (GCS) at admission and findings of preoperative computed tomography studies (CT) were collected. Operation type (subdural drainage vs. subperiostal drainage, one side vs. two sides), postoperative symptoms, time and findings of postoperative CT scan, complications, rate of recurrence- or remnant hematoma, rate of mortality, duration of hospitalization and Glasgow Outcome Scale (GOS) [7] were noted as well. At the time of follow up

remaining neurological symptoms, CT findings, rate of reoperation, mortality and Glasgow Outcome Scale (GOS) were analyzed.

Surgery and postoperative treatment:

All patients included in this study underwent first time surgery for a first time diagnosed symptomatic chronic subdural hematoma after written informed consent and received double burr hole trepanation, intraoperativ irrigation with body temperature saline and intraoperative placement of a subdural or subperiostal closed drainage system. Antiplatelet and anticoagulation medication was stopped before surgery and application of Beriplex™ (CSL Behring, USA) or vitamin k (Konakion™, Roche, Basel, Switzerland) was administered if needed to establish normal clotting parameters. Antiepileptic medication was given only in patients presenting with seizures before admission. In all cases surgery was performed during general anaesthesia and patients were placed in supine position with the head on a plastic ring without Mayfield fixation. A single shot antibiotic prophylaxis with 1g Cefazoline (Kefzol™, TEVA Pharmaceutical Industries Ltd., Tel Aviv, Israel) was given to all patients directly before skin incision. In all cases, skin incisions and burr holes were placed above the superior temporal line and dura mater was opened and coagulated. Subdural irrigation was performed with body tempered saline solution. After evacuation of the hematoma a drainage system was inserted. Whether to place a subdural or a subperiostal drainage system was decided by the surgeon during surgical planning. In case of placement of a subperiostal drainage system a redon drain Ch10 (B.Braun Medical AG, Melsungen, Germany) was inserted subperiostally and placed with its holes across the two burr holes (Figure 01). In case of placement of a subdural drainage system a nelaton bladder catheter Ch10 (Rüsch, Kernen i.R., Germany) was inserted through the posterior burr hole and gently pushed forward in

the subdural space (Figure 02). Either drain was then pulled through a small skin incision posterior to the posterior burr hole and connected to a urine collecting bag with non return valve and drainage device (Dahlhausen, Cologne, Germany). The drainage system was placed just below head level. The posterior skin incisions were closed first and then the subdural space was filled with body tempered saline before closing the anterior skin incisions to minimize intracranial air collections. Postoperatively, the patients were transferred to an intermediate or intensive care unit for postoperative observation for 6 to 24 hours. Afterwards they were transferred to the general ward. Low dose heparin prophylaxis was given in all cases starting within the first 48 hours after surgery as well as compression boots. Postoperative CT scan was performed within the first 24 hours after surgery. The findings on CT (hematoma size, maximum thickness of the hematoma, midline shift, secondary neuroradiological diagnosis) were measured and complications recorded. Forty-eight hours after surgery the drainage system was removed and thereafter the patients were mobilized. Approximately one week after surgery, patients were discharged, transferred to rehabilitation clinics in cases of persisting severe neurological deficits or regional hospitals in case of need for further - not hematoma related - medical treatment.

Follow-up:

Three month after surgery patients were seen again at the outpatient department. Persisting neurological deficits, general condition and GOS were examined. Follow-up CT scan was performed in all patients and neuroradiological findings (hematoma size, midline shift, secondary diagnosis, subdural fluid collections) were analyzed.

Statistical analysis and neuroimaging:

The statistical analysis was performed using Microsoft Excel and SPSS Statistic software. The correlation of the investigated parameters was statistically analyzed by using Student's t-Test, Fisher's exact test and chi-quare test. Statistical significance was assumed at a level of $p<0.01$.

All CT scans were performed on a 16 slice Siemens SOMATON® Sensation acquiring non contrast-enhanced 4mm axial slices. The CT scans were analyzed independently and blinded to the clinical outcome using standardized software (picture archiving and communication system, PACS). Hematoma size, maximum hematoma width, hematoma remnant/-recurrence, midlineshift, hygroma formation and secondary neuroradiological diagnosis were noted. Hematoma remnant/-recurrence were noted in case of hyperdens structures bigger than 1ccm in size. We differentiated between subdural irrigation fluid, hematoma remnant/-recurrence and subdural hygroma formation.

Results:

Study and general patients characteristics:

One hundred thirteen patients underwent surgery for 143 symptomatic chronic subdural hematomas (scSDH) (Table 01). Forty-eight patients received treatment with subperiostal drainage (spd) for 21 left sided, 20 right sided and 7 bilateral cSDH. Sixty five patients received treatment with subdural drainage (sdd) for 14 left sided, 28 right sided and 23 bilateral cSDH. There were 32 male patients (66.7%) in the group treated with spd and 45 male patients (69.2%) in the group treated with sdd. The mean age was 77 years in the spd group and 71 years in the sdd group ($p = 0.015$). In the spd group there were 11 patients (22.9%) on oral anticoagulation and 17 patients (35.4%) on antiplatelet medication. In the sdd group there were 18

patients (27.7%) on oral anticoagulation and 16 patients (24.6%) on antiplatelet medication. The most frequent secondary diagnoses were hypertension (47.9% subperiostal drain group / 44.6% subdural drain group), diabetes type II (8.3% / 6.1%), cardiac arrhythmia (16.7% / 15.4%), coronary disease (14.6% / 20.0%), COPD (4.2% / 6.1%), chronic renal disease (14.6% / 13.8%), malignant tumor (18.7% / 13.8%) and history of stroke (12.5% / 10.7%). There were no statistically significant differences regarding these parameters between the two groups (range of p-values: 0.021-1.000).

Peri-/postoperative complications:

Complications were divided into surgery related complications such as clinical significant hematoma remnant or recurrence and intracerebral hematoma and other complications such as urinary tract infection, pneumonia and thrombosis (Table 02).

In the spd group surgical complications occurred in 8.3% of patients or 7.3% of hematomas. There was a clinical significant hematoma remnant in 6.2% of patients or 5.4% of hematomas. There was a hematoma recurrence during hospitalization in 1.8% of patients or 1.5% of hematomas. No case of postoperative intraparenchymal hematoma was found. Those complications led to four reoperations. In three cases hematoma re-evacuation was performed using the existing burr hole craniotomies and in one case craniotomy was done to evacuate the recurrent hematoma.

In the sdd group there was an overall surgical complication rate of 10.3% of the patients or 7.9% of hematomas. There was a clinical significant hematoma remnant in 1.5% of patients or 1.1% of hematomas. There was hematoma recurrence in 3.1% of patients or 2.3% of hematomas and there were postoperative intraparenchymal hematomas in 6.1% of patients or 4.5% of hematomas.

There were no statistically significant differences between the two groups regarding those complications (range of p-values: 0.135-1.000). Regarding non surgical complications there were urinary tract infections in 25.0% of the patients in the spd group and in 21.5% of the patients in the sdd group. Pneumonia was found in 6.2% of the patient in the spd group and 13.8% of patients in the sdd group. Other non surgical complications were present in 12.5% of the patients in the spd group and 13.8% of the patients in the sdd group. There was no statistically significant difference between the two groups (range of p-values: 0.231-0.920). There was no case of wound infection in both groups. There was one case of mortality during hospitalization in the sdd group (due to a postoperative intraparenchymal hematoma) but none in the spd group.

Hematoma size and neuroradiological findings:

All patients underwent preoperative and postoperative CT scan (Table 03). Nearly all patients, 95.8% in the spd group and 95.4% in the sdd group within the first 24 hours after surgery. All patients seen for follow-up examination three month after surgery underwent another CT scan. There were no differences in mean hematoma size, mean midline shift and mean coronar width of hematoma between the two groups (range of p-values: 0.176-0.857) at preoperative-, postoperative- or follow up CT scan. Postoperatively there was a significant drop in coronar hematoma width compared to the preoperative imaging studies in both groups ($p<0.001$). In the group with spd the mean coronar width was 20.37mm in the preoperative, 5.75mm in the postoperative and 1.55mm in the follow up CT scan at three month after surgery. In the group with sdd the mean preoperative hematoma width was 19.51mm, 5.75mm in the postoperative imaging and 0.93mm at follow up.

The mean hematoma volume dropped postoperative significantly in both groups. In the group with subperiostal drainage from $119*10^3mm^3$ to $8*10^3mm^3$ ($p<0.001$) and in the group with subdural drainage from $108*10^3mm^3$ to $8*10^3mm^3$ ($p<0.001$). There was another but not significant drop in mean hematoma size in the group with spd from $8*10^3mm^3$ to $6*10^3mm^3$ ($p=0.448$) and a significant drop in the group with sdd from $8*10^3mm^3$ to $2*10^3mm^3$ ($p<0.001$) between the postoperative CT scan and the CT scan at follow up.

Preoperative symptoms: (Table 04a):

The most frequent preoperative symptoms included paresis (52.1% spd group / 52.3% sdd group), aphasia (22.9% / 32.3%), headache (62.5% / 67.7%), imbalance (81.3% / 50.8%), epileptic seizures (12.5% / 6.2%) and acute state of confusion (58.3% / 47.7%). There was a significant higher percentage of patients with imbalance in the group with spd ($p<0.001$) but no other statistically significant difference between the two groups regarding the preoperative symptoms (range of p-values: 0.319-0.862). The mean GCS at admission was 14.2 in both groups ($p=0.920$).

Postoperative symptoms and outcome (Table 04b):

Patients were examined again after surgery regarding the preoperative symptoms. There was a drop of the frequency of nearly all preoperative symptoms in both groups. Frequency of paresis (52.1% to 10.4% spd group / 52.3% to 13.8% sdd group), aphasia (22.9% to 4.2%/ 32.3% to 10.8%), headache (62.5% to 12.5%/ 67.7% to 23.1%), imbalance (81.3% to 43.8%/ 50.8% to 24.6%), epileptic seizures (12.5% to 2.1%/ 6.2% to 6.2%) and acute state of confusion (58.3% to 18.8%/ 47.7%

to 15.4%). Except for epileptic seizures patients in both groups had statistically significant less symptoms postoperative ($p<0.001$).

The mean hospitalization time was 9.6 days in the spd group and 9.1 days in the sdd group ($p=0.818$). The mean GOS at discharge was 4.3 in the spd group and 4.2 in the sdd group ($p=0.772$).

Symptoms at follow up and long-term outcome (Table 04c):

Follow up was scheduled for three months after surgery. The patients were seen after an average time of 68 days in the spd group and after 90 days in the sdd group ($p=0.022$). There was a loss to follow up of 16.6% of patients in the spd group and 21.5% in the sdd group ($p=0.689$). The mean GOS was 4.8 in both groups ($p=0.597$) and there was a persisting minor hematoma in 22.2% in the spd group and 19.6% in the sdd group ($p=0.920$). The rate of persisting hematoma related symptoms was 16.7% in the spd group and 17.6% in the sdd group ($p=0.920$). There was additional surgery for remnant or recurrence hematoma in 20.0% of the spd patients and 6.8% of the sdd patients within the first year after primary surgery. The overall mortality rate within the first year after primary surgery was 2.1% in the spd group and 10.7% in the sdd group ($p=0.135$).

Discussion:

Symptomatic chronic subdural hematoma is one of the most frequent diagnosis in neurosurgical practise mainly found in elderly patients [1,3,5,18]. As life expectancy worldwide especially in developing countries has experienced a steady growth and antiplatelet and anticoagulation therapy is widely available, incidence of chronic subdural hematoma is becoming an even more frequent diagnosis [1,3,5,18]. The recommended treatment of scSDH is surgery with burr hole trepanation, irrigation

and placement of a closed drainage system [19]. This procedure is safe, effective, technically easy and cost-efficient [19,20]. Widely used is the method described by Tabaddor and Shulman with burr hole craniostomy and placement of a subdural drainage system [16] and all newly established procedures have to prove their value as an alternative compared to this method. In 2007, a study by Gazzeri et al was published about the treatment of scSDH with single burr hole craniostomy and placement of subgaleal closed drainage system instead of subdural closed drainage system showing lower rates of complications and recurrent hematoma than previously published series [4]. Recent studies by Taussky et al and Han et al pointed out that double burr hole craniotomy instead of single burr hole craniotomy shows favourable outcome and a lower rate of recurrent subdural hematoma [6,17]. Another randomized controlled study showed the positive effects of subdural drainage placement in operative treatment of scSDH [14]. In 2009 Zumofen et al published the first series of patients treated with placement of subperiostal drainage system instead of the widely used subdural drainage system after double burr hole craniotomy for hematoma evacuation [20]. This study showed equal to superior results compared to previous studies regarding hematoma recurrence, mortality and serious complications especially postoperative seizures. To further analyze the method of subperiostal drainage placement we compared this technique with the widely used procedure of subdural drainage placement for the treatment of scSDH for the first time in a single centre study.

Patient characteristics, mean hematoma size, preoperative patient condition, antiplatelet and anticoagulation therapy, secondary diagnosis, preoperative symptoms and operative settings were comparable without significant differences between the two groups in this study. Patients in both groups were operated by the same surgeons and postoperative management took place at the same intensive

care unit and general ward and included the same postoperative management regarding removal of drainage, mobilisation, physiotherapy and medical treatment.

Both methods proved being effective in the treatment of scSDH as in both groups mean hematoma size and preoperative symptoms dropped significantly after surgery. In accordance to the findings of Zumofen et al the rate of epileptic seizures dropped after surgery in the spd group[5]. However the differences were not statistically significant. In the sdd group operation had no effect on epileptic seizures during time of hospitalization.

Overall surgical complications in both groups (8,5% spd group / 10,7% sdd group) were comparable to those previously published in the literature (4,6%-20,5%) [2,5,9-11,13,20]. Medical complications could hardly be compared with previous publications as included diagnosis varied. The medical complication rates in the two groups of our study (43.8% spd group / 49,2% sdd group) were significantly higher as reported in previous publications about treatment of scSDH with burr hole craniotomy and placement of closed drainage systems [2,5,9,10,13,20]. However, in contrast to other publications, we included urinary tract infection, which accounted for around 50% of medical complications in our study.

We defined good outcome as reduction of preoperative symptoms and a low mortality and morbidity rate. Reduction of preoperative symptoms could be achieved significantly in both study groups as shown above. Overall mortality (2.1% spd group / 10.7% sdd group) was slightly superior to previously published data (2.1-13.3%) [5,10,13,15,20] especially as we included all patients who died before follow up. General outcome (GOS 4.3 spd group / GOS 4.2 sdd group) was fairly good in the present study despite significant comorbidities and the high mean patient age (77 years spd group / 71 years sdd group). Comparison of the outcome with previously

published studies turned out to be difficult, as time of evaluation and time of follow up as well as used outcome scales were non-uniform and results widely differed. Zumofen et al used comparable outcome scales at time of follow up and reported a comparable good outcome in 183 scSDH three month after surgery [20].

The two groups showed no significant differences regarding mean postoperative hematoma size and postoperative symptoms. Overall medical and surgical complications, outcome at discharge and at follow-up were comparable without significant differences although there was a tendency towards a lower rate of hematoma remnant and recurrence in the sdd group and a tendency towards lower rate of intraparenchymal hematoma and lower mortality in the spd group.
The studies by Zumofen et al and Gazzeri et al indicate the advantages of placement of subperiostal closed drainage systems regarding rates of hematoma recurrence and serious complications [4,20]. This could especially been shown for elderly patients. For this reason we compared in a second step the study groups including only patients older than 80 years (25 with spd, 18 with sdd). We did not find different results in those subgroups. However the tendency towards lower mortality in the group treated with placement of subperiostal drainage was closer to significance ($p=0.021$). This effect has to be proven by means of follow up-studies with larger patient numbers.

Overall we found no statistically significant differences regarding the preoperative condition and general data of the patients, the postoperative symptoms, the postoperative hematoma remnant, the rates of recurrent hematoma and mortality, the medical and surgical complications and the outcome at discharge and at three month

follow up between the groups treated with spd and sdd after double burr hole craniotomy and intraoperative irrigation.

Nevertheless the results suggest that patients with predictable high risk of complications – especially older patients - can benefit from placement of a subperiostal drainage system instead of a subdural drainage system in surgery for scSDH due to the minor invasiveness of the surgical procedure, however accepting a slightly higher probability of hematoma recurrence. As the tendency for a lower rate of serious complications, a lower rate of mortality and a lower rate of postoperative epileptic seizures could not shown to be statistically significant in this study, further studies with higher numbers of patients and prospective study design need to be initiated.

Conclusions:

Our study shows for the first time a direct comparison of spd and sdd treatment in scSDH. Both methods have proven to be highly effective in the treatment of cSDH. General patient data, complications, outcome and mortality of both investigated study groups are comparable or superior to previously published series. As there is a clear tendency to less mortality and less serious complications and despite a slightly higher rate of hematoma remnant or recurrence, the treatment with double burr hole trepanation, irrigation and placement of subperiostal drain is our treatment of choice in patients with predictable high risk of complications especially in patients older than 80 years.

Legends:

Figure 01: Postoperative CT scan after subperiostal drainage placement

A: Lateral view of high resolution 3D reconstruction

B: Medial view of high resolution 3D reconstruction

C: Axial view of soft tissue

D: Coronal view of soft tissue

Figure 02: Postoperative CT scan after subdural drainage placement

A: Lateral view of high resolution 3D reconstruction

B: Medial view of high resolution 3D reconstruction

C: Axial view of soft tissue

D: Coronal view of soft tissue

Table 01: Study and patients characteristics

Table 02: Surgical characteristics and peri-/postoperative complications

Table 03: Results regarding haematoma size and other neuroradiological findings

Table 04: Results regarding pre-/postoperative symptoms and outcome

Conflicts of interest:

The authors declare that they have no conflict of interest.

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Subdural drainage vs. subperiostal drainage in burr hole trepanation for symptomatic chronic subdural hematomas

A single centre experience of 113 cases

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Abbreviations:

cSDH	**chronic subdural hematoma**
scSDH	**symptomatic chronic subdural hematoma**
GCS	**Glasgow Coma Scale**
CT	**computed tomography**
GOS	**Glasgow Outcome Scale**
PACS	**picture archiving and communication system**
spd	**subperiostal drainage**
sdd	**subdural drainage**

	Trepanation and subperiostal drain		Trepanation and subdural drain	
Number of patients	48		65	
Mean age in years (SD)	77 (±13)		71 (±13)	
Sex distribution, male	32	66.7%	45	69.2%
Left side subdural haematoma	21	43.8%	14	21.5%
Right side subdural haematoma	20	41.2%	28	43.1%
Bilateral subdural haematoma	7	14.6%	23	35.5%
Patients on				
Oral anticoagulation medication	11	22.9%	18	27.7%
Antiplatelet medication	17	35.4%	16	24.6%
Most frequent secondary diagnoses				
Hypertension	23	47.9%	29	44.6%
Diabetes Mellitus II	4	8.3%	4	6.1%
Cardiac arrtythmia	8	16.7%	10	15.4%
Coronary disease	7	14.6%	13	20.0%
COPD	2	4.2%	4	6.1%
Chronic renal disease	7	14.6%	9	13.8%
History of malignant tumor	9	18.7%	9	13.8%
History of stroke	6	12.5%	7	10.7%

SD = standard deviation, COPD = Chronic Obstructive Pulmonary Disease

	Trepanation and subperiostal drain				Trepanation and subdural drain			
	p.Pat. n=48	%	p.Hae n=55	%	p.Pat. n=65	%	p.Hae n=88	%
Left side unilat. trepanation	21	43.8			14	21.5		
Right side unilateral trepanation	20	41.2			28	43.1		
Bilateral trepanation	7	14.6			23	35.5		
Mortality during hospitalisation	0	0.0	0	0.0	1	1.5	1	1.1
Mortality during follow up	1	2.1	1	1.8	6	9.2	6	6.8
Overall mortality	1	2.1	1	1.8	7	10.7	7	7.9
Mortality in patients > 80years	0	0.0	0	0.0	4	6.1	4	4.5
Reoperations while hospitalised	4	8.3	4	7.3	3	4.6	3	3.4
Re-Evacuations	3	6.2	3	5.4	2	3.1	2	2.3
Craniotomies	1	2.1	1	1.8	0	0.0	0	0.0
Decompressive craniotomies	0	0.0	0	0.0	1	1.5	1	1.1
Reoperations during follow up	7	14.5	7	12.7	4	6.1	4	4.5
Overall complications	25	52.1	25	45.4	39	60.0	39	44.3
Clinical remnant	3	6.2	3	5.4	1	1.5	1	1.1
Recurrence of hematoma	1	1.8	1	1.6	2	3.1	2	2.3
Intracerebral hematoma	0	0.0	0	0.0	4	6.1	4	4.5
Urinary tract infection	12	25.0	12	21.8	14	21.5	14	15.9
Pneumonia	3	6.2	3	5.4	9	13.8	9	10.2
Wound infection	0	0.0	0	0.0	0	0.0	0	0.0
Other complications	6	12.5	6	10.9	9	13.8	9	10.2
Surgical complications	4	8.3	4	7.3	7	10.7	7	7.9
Medical complications	21	43.8	21	38.2	32	49.2	32	36.4

p.Pat. = per patient, p.Hae = per hematoma

	Trepanation and subperiostal drain			**Trepanation and subdural drain**		
	preop	postop	follow up	preop	postop	follow up
Coronar width of hem	20.4±6.33	5.75±4.96	1.55±4.01	19.5±5.99	5.08±5.15	0.93±2.98
Mean size of hem *10^3	119±57.2	8±15.4	6±20.7	108±48.3	8±11.9	2±10.3
Hematomaremnant	-	34/61.8%	8/14.5%	-	49/55.7%	10/11.4%
Mean midlineshift	7.37±3.97	3.65±2.82	-	6.90±4.96	3.03±2.78	-
Postoperativ hygroma	-	-	12/33.3%	-	-	20/39.2%

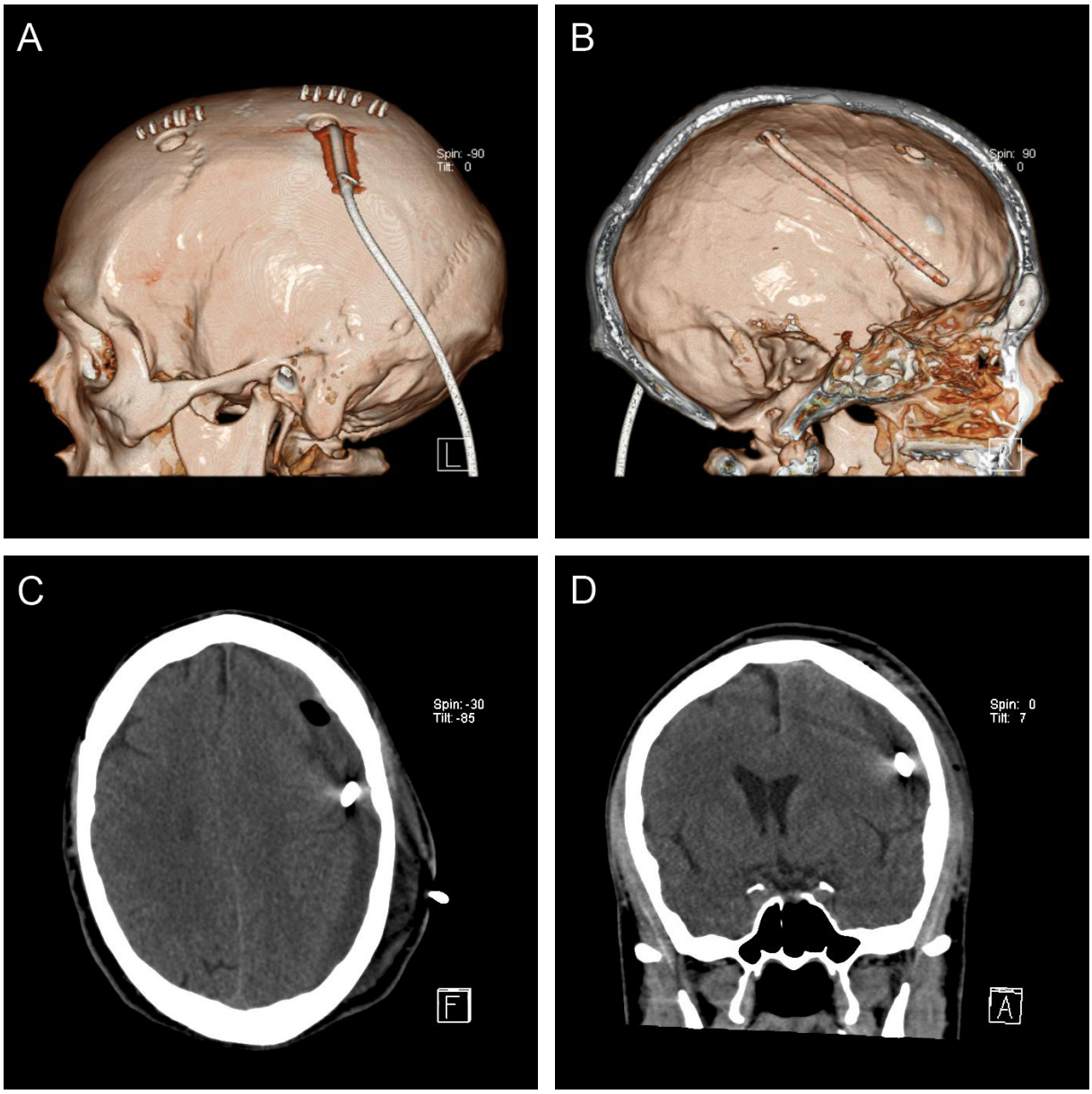
hem = hematoma, preop = preoperative, postop = postoperative

A: Preoperative Symptoms	Trepanation and subperiostal drain		Trepanation and subdural drain	
	Pat.	SD / %	Pat.	SD / %
Mean GCS at admission	14.2	1.56	14.2	1.78
GCS 13-15	43	89.6%	61	93.8%
GCS 9-12	4	8.3%	3	4.6%
GCS 3-8	1	2.1%	1	1.5%
Symptoms at admission				
Paresis	25	52.1%	34	52.3%
Aphasia	11	22.9%	21	32.3%
Headache	30	62.5%	44	67.7%
Imbalance	39	81.3%	33	50.8%
Epileptic seizures	6	12.5%	4	6.2%
Acute state of confusion	28	58.3%	31	47.7%

B: Postoperative Symptoms and outcome	Trepanation and subperiostal drain		Trepanation and subdural drain	
	Pat.	SD / %	Pat.	SD / %
Mean hospitalisation (days)	9.6	5.30	9.1	5.77
Postoperative CT within 12h	20	41.7%	20	30.7%
Postoperative CT within 24h	46	95.8%	62	95.4%
Mean GOS at discharge	4.3	0.55	4.2	0.81
GOS 5	18	37.5%	26	40.0%
GOS 4	28	58.3%	28	43.1%
GOS 3	2	4.2%	10	15.4%
GOS 2	0	0.0%	0	0.0%
GOS 1	0	0.0%	1	1.5%
Symptoms at discharge				
Paresis	5	10.4%	9	13.8%
Aphasia	2	4.2%	7	10.8%
Headache	6	12.5%	15	23.1%
Imbalance	21	43.8%	16	24.6%
Epileptic seizures	1	2.1%	4	6.2%
Acute state of confusion	9	18.8%	10	15.4%

C: Symptoms at follow up and long term outcome	Trepanation and subperiostal drain		Trepanation and subdural drain	
	Pat.	SD / %	Pat.	SD / %
Mean follow up after (days)	68	34	90	48
Loss to follow up	8	16.6%	14	21.5%
Mean GOS at follow up	4.8	0.40	4.8	0.46
GOS 5	30	83.3%	41	80.4%
GOS 4	6	16.6%	9	17.6%
GOS 3	0	0.0%	1	1.9%
GOS 2	0	0.0%	0	0.0%
GOS 1	0	0.0%	0	0.0%
Persisting hematoma remnant	8	22.2%	10	19.6%
Mortality during follow up	1	2.1%	6	10.5%
Persisting hematoma related symptoms	6	16.7%	9	17.6%
Overall Reoperation	11	20.0%	6	6.8%

GCS = Glasgow Coma Scale, Pat. = number of patients, SD = standard deviation, CT = computed tomography, GOS = Glasgow Outcome Scale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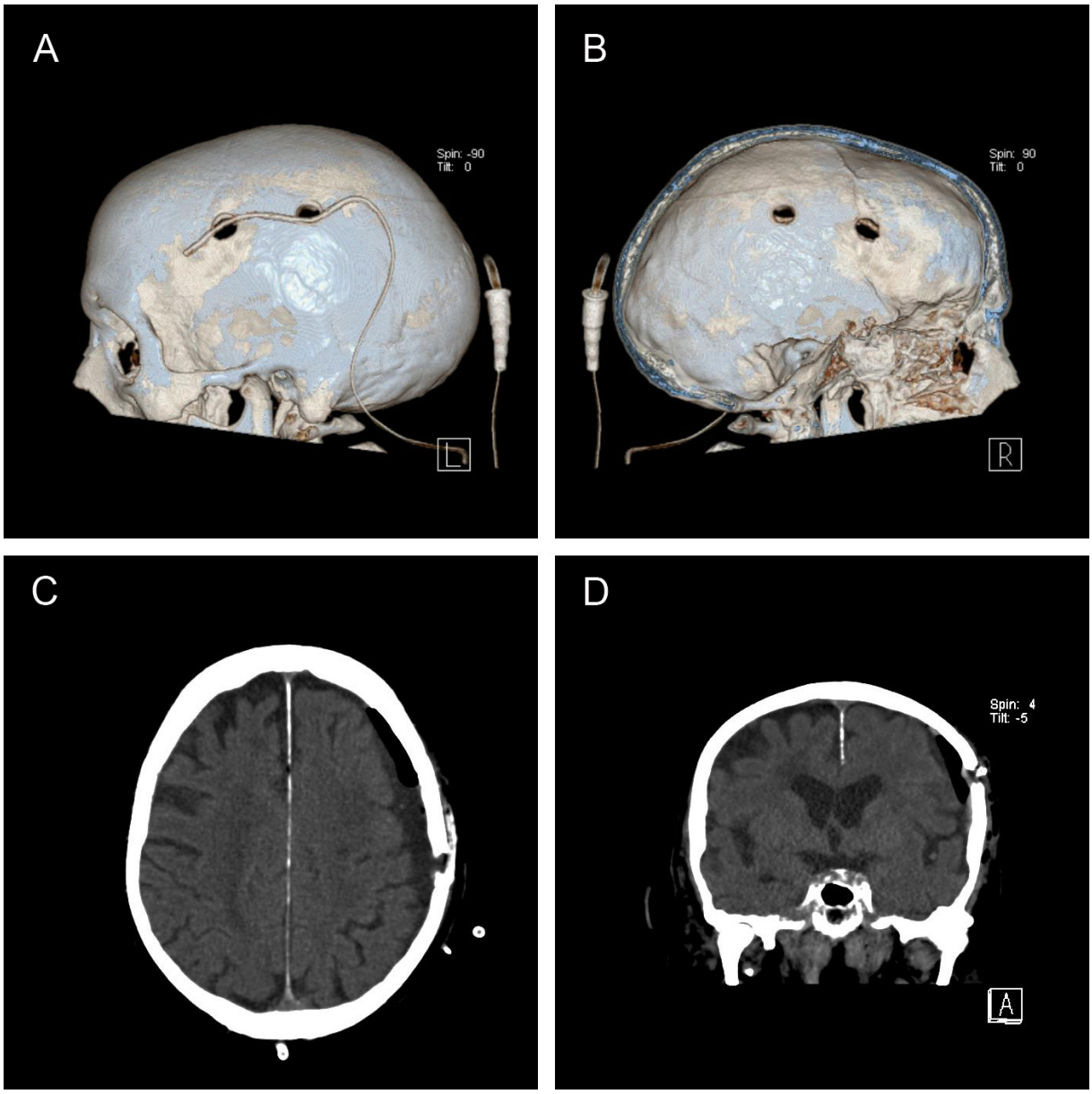
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